Scope of Review – Changes to AMS for Permanent Magnet Option

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Prepared
26 April 2010

http://ams.nasa.gov
http://www.ams02.org

Scope of Review

- AMS has been through numerous reviews over the past ten years (including full PDR, CDR, Phased FSRs and GSRs, DOE Science Reviews)
- The scope of this review will be limited to the proposed changes to the system and the impact of those changes on all the various NASA organizations
- What is in scope:
  - Items related directly to removal of the superconducting magnet and its associated systems
  - Items related directly to the installation of the permanent magnet
  - Items related to the repositioning of Tracker Planes
  - Items related to operations (pre-launch and on-orbit) associated with the removal of the cryogenic systems of AMS
  - Items related to the operations (pre-launch and on-orbit) associated with the installation of a permanent magnet
- RIDs that focus on areas that are not being changed will be reviewed and discussed by the team. Once reviewed they will likely be tagged for removal by the RID board. If the RID board agrees with the teams recommendation, those RIDs not directly related to the changes will receive no further consideration

Integration Plan

- In order to accomplish the AMS magnet change-out and deliver to KSC for a launch in 2010 the following tasks must be completed
  - Payload must be prepared to accept permanent magnet
  - Complete the integration of the permanent magnet into the Flight Spare Vacuum Case in Aachen
  - Prepare the new Tracker planes
  - Correct minor issues identified in TVT
    - Provide list of TVT anomalies and resolution plan
  - Reintegrate updated AMS-02
    - Install the permanent magnet
    - Reintegrate detectors including new Tracker planes
  - Perform Beam Test at CERN to realign the experiment
  - Ship to KSC
  - Perform offline and online activities at KSC
  - Install in Orbiter
  - Launch to ISS
  - Install on ISS
  - Turn on the payload and operate for 10-15 years

Payload Changes

- In order to accomplish this modification, the following mechanical changes have to be completed:
  - Remove
    - Cryogenic
      - Superconducting magnet
      - Cryomagnet support hardware (VC external hardware)
      - Warm Helium Tank and WHT MMOD Shield
      - Cryomagnet Avionics Box Loop Heat Pipe, accumulators, and evaporators
      - Cryocoolers
      - Vacuum Case Burst Disks
      - Cryomagnet Burst Disks
      - Composite Support Straps
      - Superfluid Helium Tank
      - Cryo Plumbing
      - Cryocooler Loop Heat Pipe
    - Electrical
      - Cryomagnet Avionics Box
      - UPS
      - On board pump and cabling
      - Baroswitch Electronics and Cryomagnet Pilot Valve Switch Box
      - Vacuum Pump Cabling
      - Charge/Discharge Cabling
      - Cryomagnet Dump Diodes
      - CCEB Electronics (Leave Box On)
      - Reconfigure NASA JSC integration cabling
    - Thermal
      - Zenith Radiator
      - MLI to be reconfigured

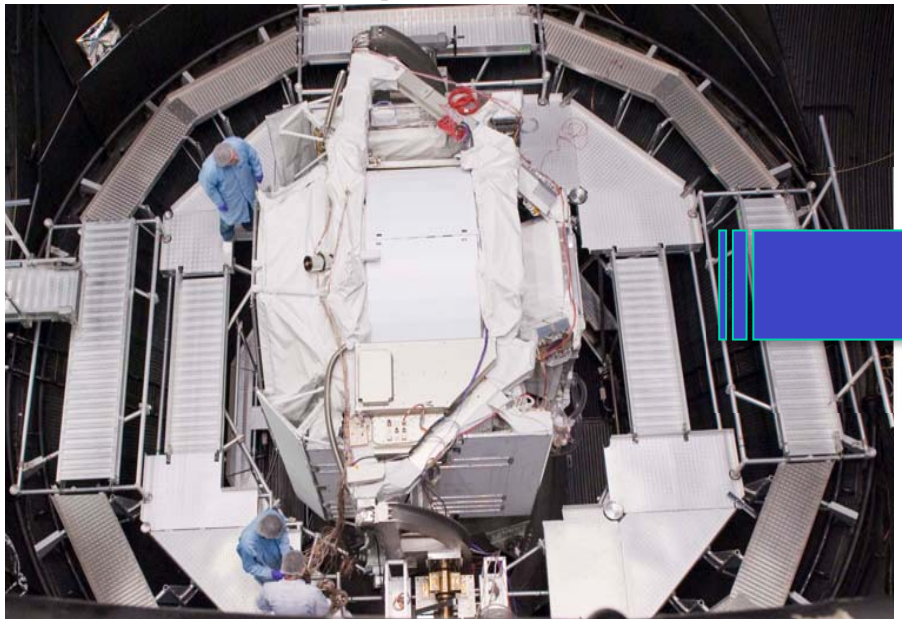
Payload Changes

- In order to accomplish this modification, the following mechanical changes have to be completed:
  - Additions
    - Permanent Magnet
    - New Double X Structures
    - New Plane 1N Support Structure
    - New Plane 5
    - New Plane 6
    - New TTCS Loop for Plane 6
    - New Heaters for Plane 1N
    - New thermal blankets, light block and containment for Plane 1N and 6
    - New Tracker Plane cabling

How do we make this happen?

- Payload has completed testing at ESTEC and will be prepared in the next few days to be shipped back to CERN

April 16

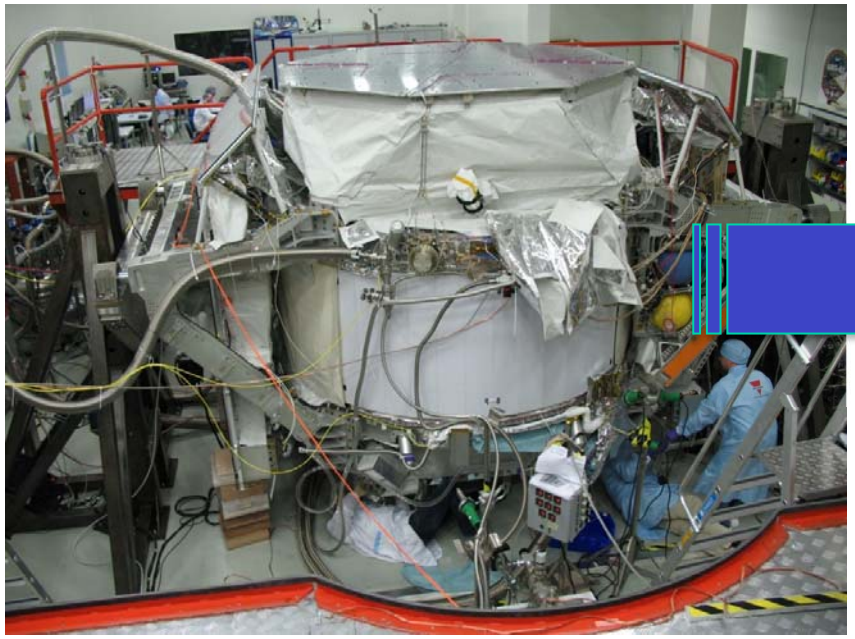


April 27

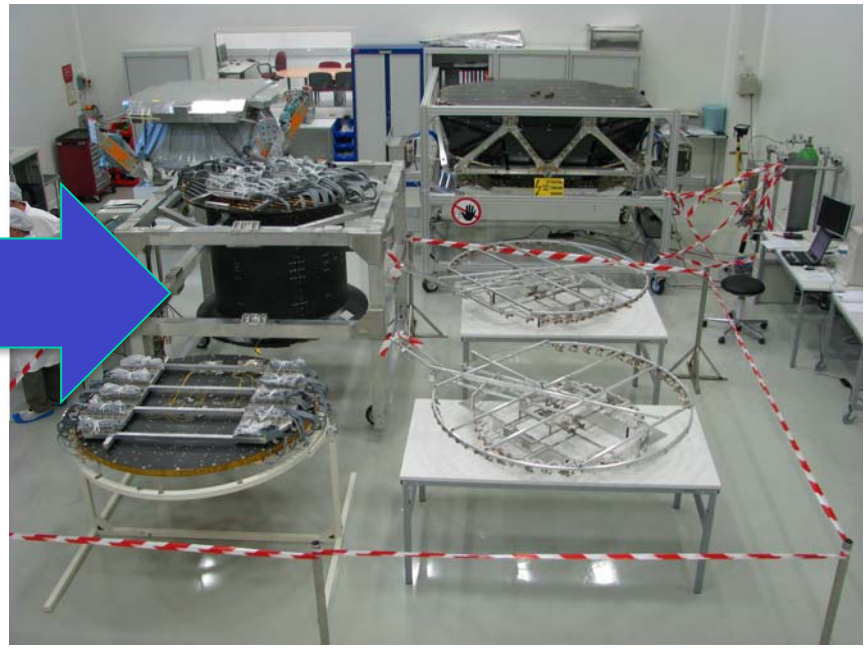
Warm Up and Deintegrate

- Warm up the superconducting magnet, deintegrate detectors and remove superconducting magnet

April 28



June 2



Permanent Magnet Work

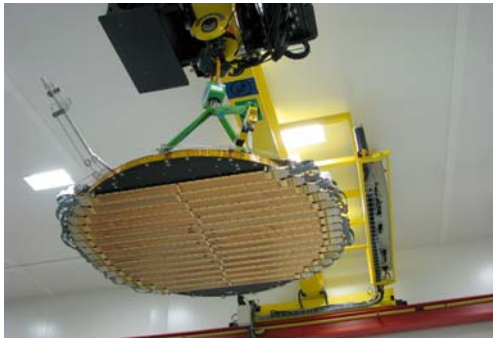
- Permanent Magnet prepared for flight
  - Will change out all accessible bolts
- Flight Spare Vacuum Case prepared to receive permanent magnet
- New Double X Structure built
- New Strut System built
- Integrate VC, Magnet, Double X Structures, and Strut System

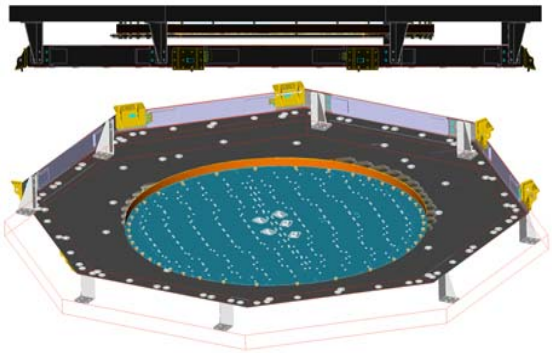
Jan 26 → May 17

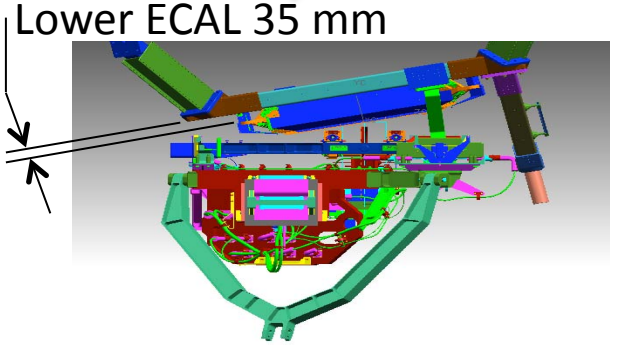
New Tracker Planes

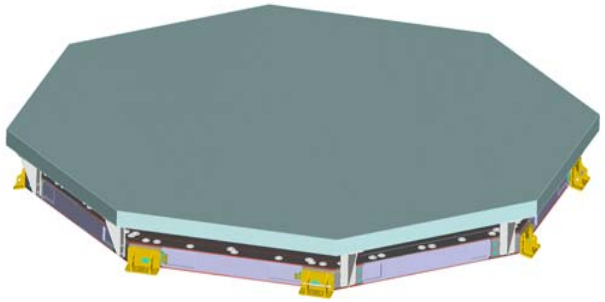
- Plane 1N (former plane 5 will be moved to the top with new attachment brackets and new support structure)
- Plane 5 will be built to match original drawings
- Plane 6 must be manufactured
- Tubing of the lower loop of the TTCS will be rerouted to attach to plane 6
- Spacer for ECAL must be built to lower it by 35 mm to allow plane 6 to fit between RICH and ECAL

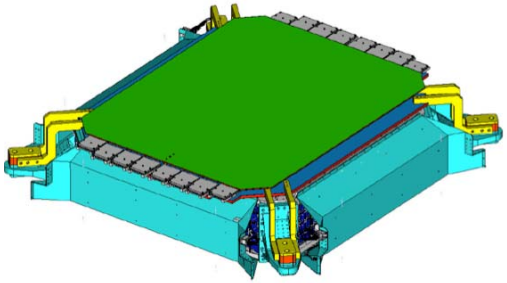
Feb 24 → June 30

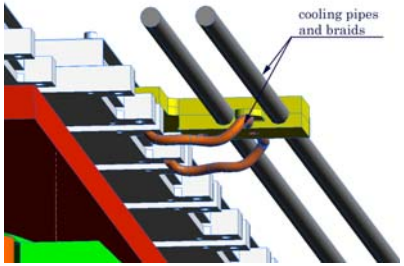












Correct Minor Issues Identified in TVT

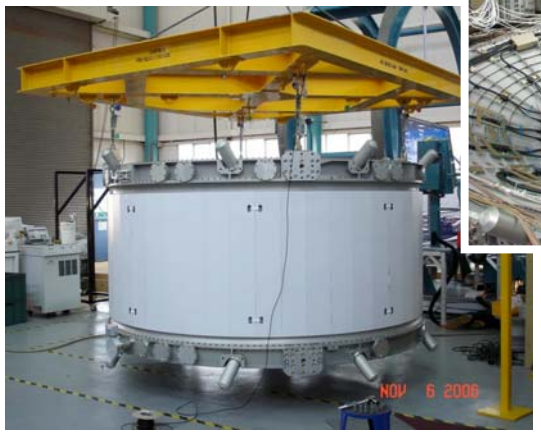
Apr 22 → July 1

Anomaly	Comment/Cause/Solution
1 LHP on CC2 never started, other difficult to start. 1 LHP on CC3 only ran briefly, other difficult to start and appears unstable, instability caused CC3 to overheat on several occasions, requiring power reduction or turning off CC.	This is a 1G effect in serpentine sections of Zenith radiator. NCR open, NRB (NCR Review Board) will convene next week (ASI-CGS-AMS) to dispose it and close, confirming LHP are suitable for flight operations (in case).
One board in S1 crate giving bad data	This was a software problem. Threshold setting at low temperature. Software has been updated. No further action.
Lower electronics heaters (E0, E1, HVE4, HVE6) do not work on Bus A. They work on Bus B.	These are all wired to the same terminal block. Likely cabling/connector problem. Will correct once payload out of TVT chamber.
TPD0 never turned on and now appears dead.	Possible short. Will investigate once it is removed from TVT.
TRDGB Xenon leak during transfer. Leak is in smaller Xe buffer volume.	Leak rate is acceptable for 57 years of operation, but will it increase? Need to replace/inspect/fix? Will investigate upon removal from TVT and will likely repair.
TRDGB Box C heaters seems undersized. Operator maintained temperature by manually cycling a valve once an hour or so (TBC).	May need to add G10 shim between C box and USS or increase heaters. To be investigated and corrected after TVT
TRD M-structure heaters may be undersized. TRD temperature gradient was outside of expectations. They required both A & B buses to maintain temperatures.	Must redo analysis with correlated model and potentially add heaters.
PDS running hotter than expected	Heat pipe configuration in test does not allow for adequate cooling. Test configuration dependant, no action required.
PDS/Wake radiator heaters/thermostats behaved oddly and could not be completely verified.	Design was primarily based on a cold startup, with only 1 Bus and all HPs working. In test the heat pipes (primarily the "L-shaped" ones) did not function as they would in space. We also had both A and B buses on. This entire heater/thermostat system needs to be re-evaluated and possibly modified.
RICH board gave "bad" data.	Software issue. Fixed during test. No further action required.
The TTCB-P Pr1bP pre-heater provides no power. (never came on)	Cabling issue? This worked in pre-test checkout. To inspect and correct post test.
ECAL Electronics, TRD Electronics, ACC Electronics boxes too cold.	This is likely due to the test configuration; the temperature was much colder than we

Reintegrate AMS-02

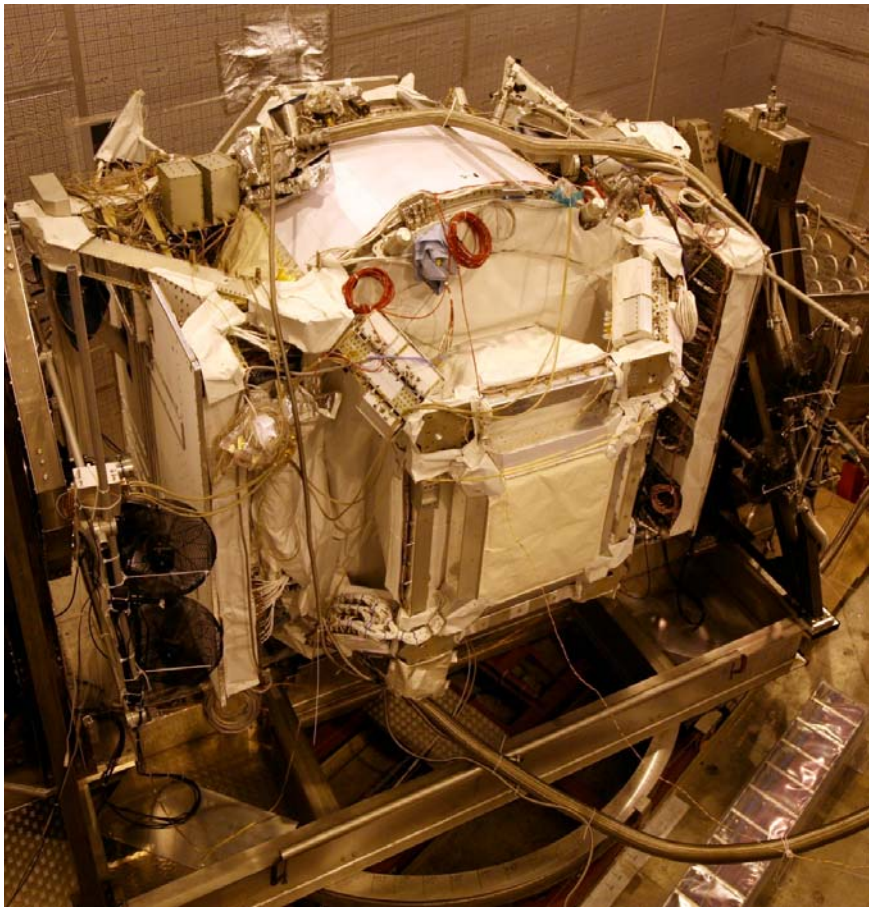
- Install the Permanent Magnet
- Reintegrate detectors including new tracker planes

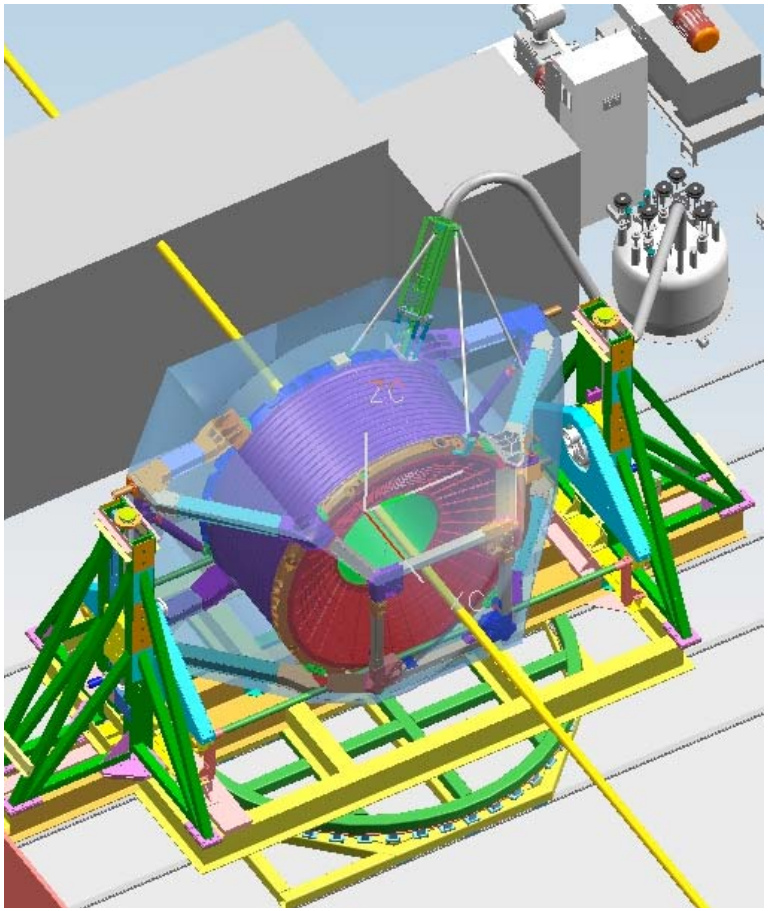
Jun 2 → Aug 10



Perform Beam Test at CERN

Aug 7 → Aug 14



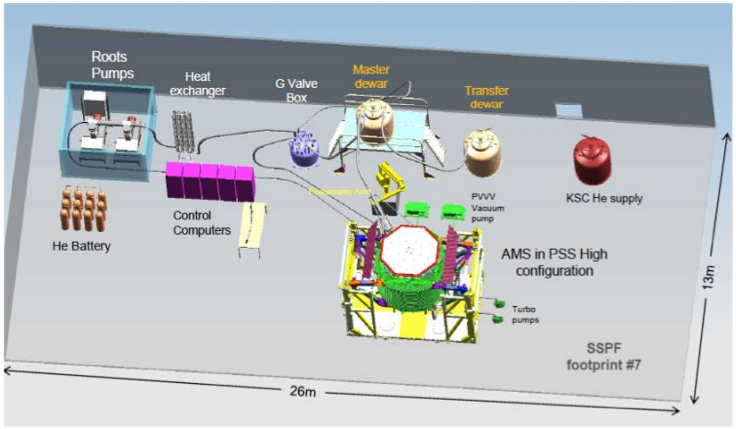


Ship to KSC

Aug 15 → 2 Weeks Contingency → Sep 1

KSC Processing and Launch

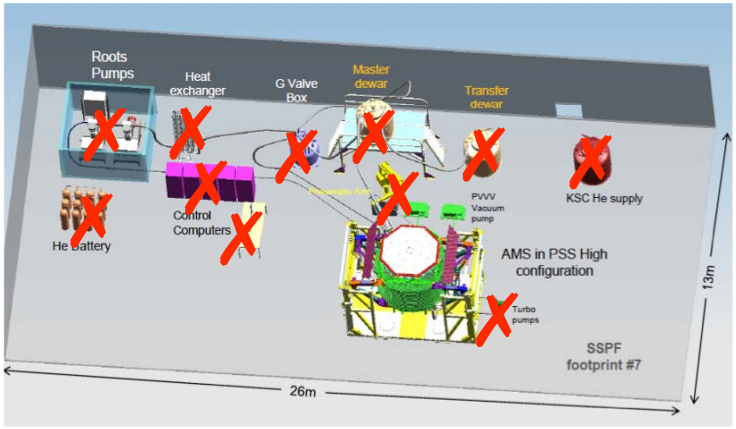
Sept 1 → Nov 15



KSC Processing and Launch

Sept 1 → Nov 15

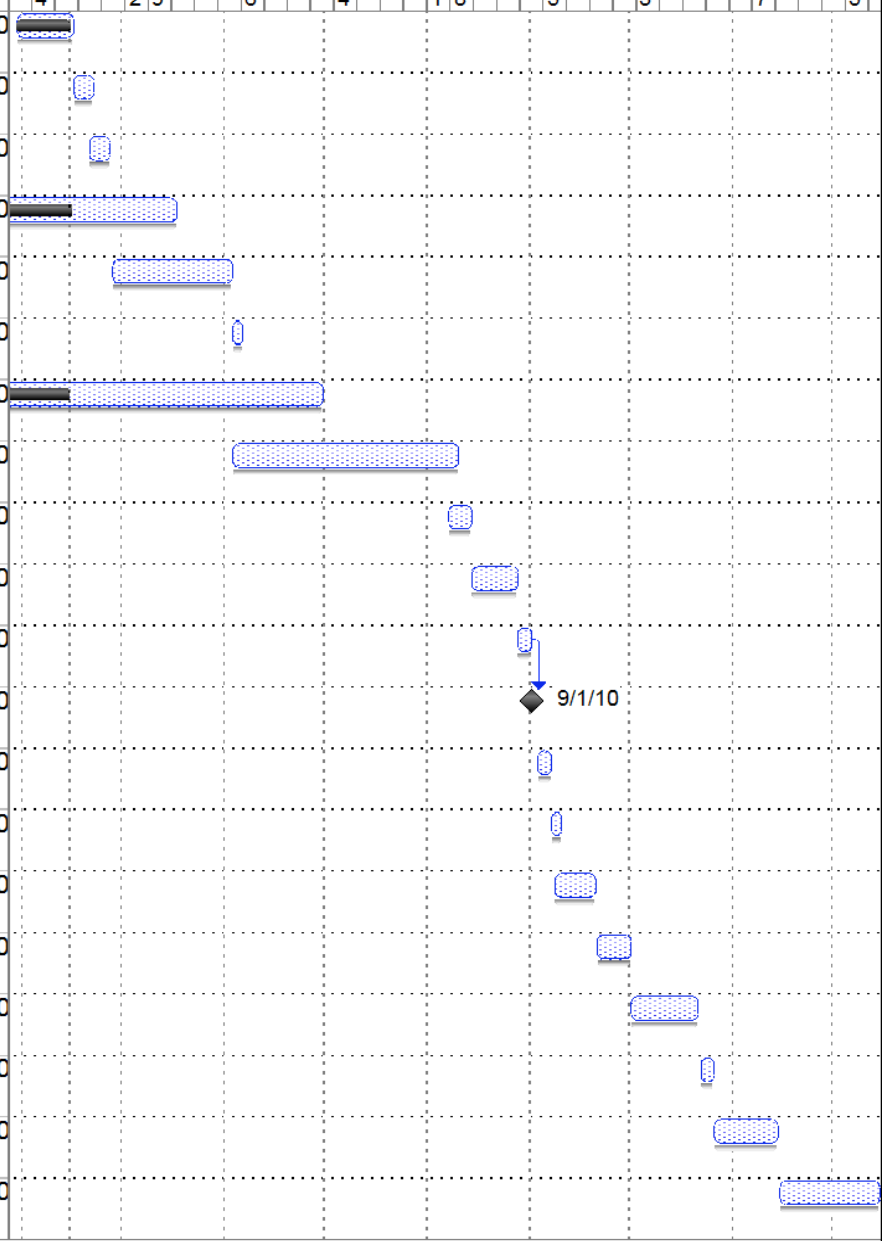
Launch Ready Date



Schedule Summary

AMS-02 Milestone Overview 4/15/2010

ID	Task Name	Duration	Start	Finish
21	TVT Testing	17 days	3/30/2010	4/16/2010
23	TVT Test Teardown	6 days	4/16/2010	4/22/2010
25	Pack AMS	7 days	4/21/2010	4/27/2010
27	Permanent Magnet Reworking/Testing	109 days	1/29/2010	5/17/2010
29	DeIntegration	36.5 days	4/28/2010	6/3/2010
31	PM Installation	3 days	6/3/2010	6/6/2010
33	Tracker Plane Manufacturing	127 days	2/24/2010	6/30/2010
35	Flight Integration	68 days	6/3/2010	8/10/2010
37	Beam Test	6.75 days	8/7/2010	8/14/2010
39	Contingency	14 days	8/14/2010	8/28/2010
41	Prepare and Ship to KSC	5 days	8/28/2010	9/1/2010
42	AMS Arrives at SSPF	0 days	9/1/2010	9/1/2010
44	Shuttle Interface Hardware Installation	4.75 days	9/3/2010	9/7/2010
46	Station Interface Hardware Installation	3 days	9/7/2010	9/10/2010
48	PRCU Testing / MLI Closeouts	12.5 days	9/8/2010	9/20/2010
50	SSPF Flight Closeouts (in ELC)	10.5 days	9/21/2010	10/1/2010
52	SSPF Flight Closeouts (in CEWS)	20.5 days	10/1/2010	10/21/2010
54	Canister and Transport	3.9 days	10/22/2010	10/26/2010
56	STS Integrated Processing	19.5 days	10/26/2010	11/14/2010
58	Launch Window	30 days	11/15/2010	12/15/2010



Weight Summary

- With the removal of the Cryomagnet, the following components will be removed
  - Cryomagnet
  - Cryocoolers and CCEB
  - Zenith Radiator and Propylene Loop Heat Pipes
  - Cryomagnet Avionics Box (CAB) & Current lead cabling
  - CAB Loop Heat Pipe
  - UPS
  - Dump Diodes and Cabling
  - Remove inner cylinder & port covers of Vacuum Case

Weight Summary

- With the addition of the permanent magnet, the following components will be added
  - Permanent magnet
  - Double X Structure & Struts
  - New structure for Plane 1N
  - Plane 5N
  - Plane 6

Weight Summary

AMS-02 WEIGHT WITH PERMANENT MAGNET

(IN ORBITER PAYLOAD BAY AND ON ISS TRUSS ONLY)

	AMS EXPERIMENT HARDWARE	April 2010 (LBS)	April 2010 (KG)
1	ANTICOINCIDENCE COUNTER (ACC) (w/ STRUCTURE TO VC)	**118**	**53.7**
2	TRACKER (w/ STRUCTURE TO VC & LASER ALIGNMENT SYSTEM)	**438**	**198.5**
3	TIME OF FLIGHT (TOF) (w/ BOTH UPPER & LOWER SUPPORT STRUCTURES)	**591**	**268**
4	TRANSITION RADIATION DETECTOR (TRD) (WITH SUPPORT STRUCTURE)	**740**	**335.5**
5	TRD GAS SUPPLY SYSTEM (WITH HOUSING, 3 TANKS, PLUMBING, VALVES, AND INTERNAL & EXTERNAL MOUNTING BRACKETS, 49.5 Kg of Xenon)	**261**	**118.4**
6	RING IMAGING CHERENKOV COUNTER (RICH) (W/MOUNTING BRACKETS TO LOWER USS-02)	**439**	**199.2**
7	ELECTROMAGNETIC CALORIMETER (ECAL) (W/ MOUNTING BRACKETS TO LOWER USS-02)	**1402**	**636**
8	ALL AVIONICS CRATES (WITH STAR TRACKER, CABLES BETWEEN CRATES, CONNECTORS, CLAMPS, MISC. MOUNTING BRACKETS, CRATE SUPPORT STRUCTURES NOT INCLUDED WITH TCS, ETC. CAB & CCEB ARE INCLUDED WITH THE CRYOMAGNET WEIGHT; ALL EXPERIMENT COMPONENT CABLE WEIGHT INCLUDED IN COMPONENT WEIGHTS)	**1285**	**583.01**
9	Permanent Magnet System (permanent magnet, 4 double X structures, 16 rod ends, bolts and shims)	**5458**	**2475.9**
10	THERMAL CONTROL SYSTEM (TCS) (INCLUDES HEAT PIPES, LOOP HEAT PIPES, PUMPS, RADIATORS, SUPPORT STRUCTURES, CONDENSERS, PRE-HEATERS, CO2 RESERVOIR, VALVES, ETC. ALSO INCLUDES SOME SUPPORT STRUCTURE THAT WILL CARRY ELECTRONICS CRATES.)	**653**	**296.1**
11	New Tracker Planes and LEPS	**252**	**114.5**
12	**AMS EXPERIMENT HARDWARE TOTAL:**	**11638**	**5278.81**

Weight Summary

AMS-02 WEIGHT

(IN ORBITER PAYLOAD BAY AND ON ISS TRUSS ONLY)

	SPACE SHUTTLE INTEGRATION HARDWARE	April 2010 (LBS)	April 2010 (KG)
13	UNIQUE SUPPORT STRUCTURE - 02 (CARRIES 14,809 lbs on STS)	1592	722
14	CRYOMAGNET VACUUM CASE (CARRIES 14,809 lbs on STS)	1450	658
15	BRACKETS, MISC. FASTENERS & HARDWARE, SAFETY WIRE	23	10
17	SHUTTLE INTEGRATION HARDWARE CONTINGENCY	0	0
19	**SHUTTLE INTEGRATION HARDWARE TOTAL:**	3065	1390

	ISS INTEGRATION HARDWARE	(LBS)	(KG)
20	ISS PAS/UMA INTERFACE HARDWARE WITH CABLES (CARRIES 14,809 lbs on ISS)	225	102
21	GRAPPLE FIXTURES (1 FRGF & 1 PVGF), BRACKETS, & CABLE TO EBCS	131	59
22	MICROMETEORITE/ORBITAL DEBRIS (M/OD) SHIELDS & SUPPORTS	102	46
23	EVA CONNECTOR PANEL, SCUFF PLATES & BRACKETS	55	25
24	PAYLOAD DISCONNECT ASSEMBLY (PDA) FOR THE REMOTELY OPERATED ELECTRICAL UMBILICAL (ROEU) WITH MOUNTING BRACKETS, CABLES & CONNECTORS	36	16
25	EVA HANDRAILS & PORTABLE FOOT RESTRAINT (PFR) INTERFACE	16	7
26	EXTERNAL BERTHING CAMERA SYSTEM (EBCS), MOUNTING BRACKETS & HEATER CABLES	25	11
27	ISS INTEGRATION HARDWARE CONTINGENCY	0	0
28	**ISS INTEGRATION HARDWARE TOTAL:**	590	268

Weight Summary

AMS-02 WEIGHT

(IN ORBITER PAYLOAD BAY AND ON ISS TRUSS ONLY)

	TOTAL WEIGHT SUMMARY	April 2010 (LBS)	April 2010 (KG)
29	AMS EXPERIMENT HARDWARE TOTAL:	**11638**	**5279**
30	SHUTTLE INTEGRATION HARDWARE TOTAL:	**3065**	**1390**
31	**TOTAL EXPERIMENT & SHUTTLE INTEGRATION HARDWARE WEIGHT:**	**14703**	**6669**
32	ISS INTEGRATION HARDWARE TOTAL:	**590**	**268**
33	**TOTAL PAYLOAD WEIGHT:**	**15293**	**6937**
34	**TOTAL CONTROL WEIGHT:**	**15300**	**6940**
35	TOTAL OVER/UNDER CONTROL WEIGHT:	**7**	**3**

Changes for ISS/STS

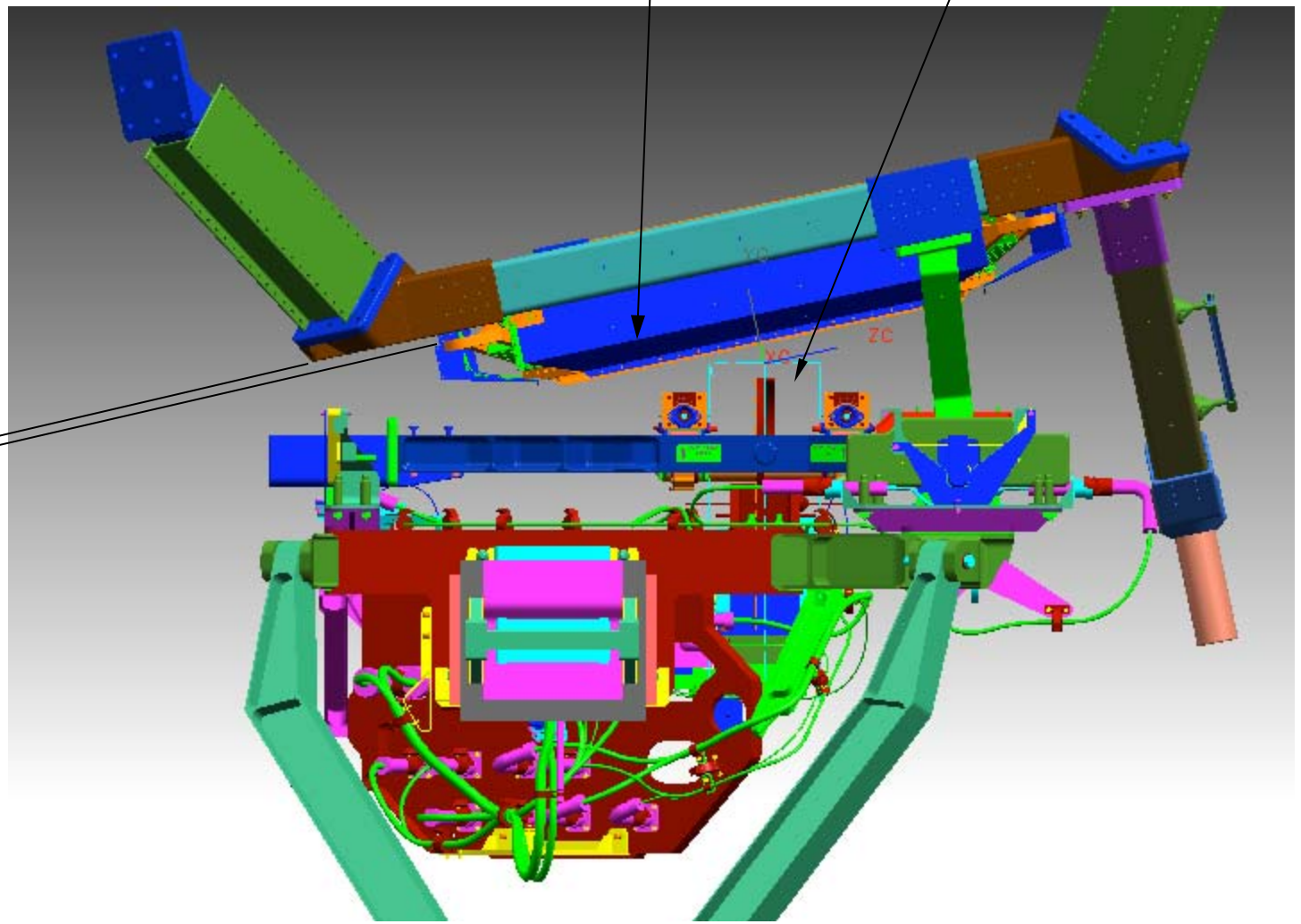
- Lowering the ECAL creates new envelope violation
- Substantially lower magnetic field, but always on
- Reduces power requirement on ISS
- No further concerns for passive thermal since endurance of cryogenic system is not longer an issue
- Operations constraints associated with the superconducting magnet are removed
  - No longer need power during ascent
  - Eliminates all three LCCs associated with potential over pressurizing the payload bay and deadfacing T-0 umbilical (will still have T-0, but will deadface prior to LCC timeframe)
  - No longer need to worry about providing large amount of power within hours of installation on ISS to charge magnet

Capture Claw Clearance Assessment
Lowering the ECAL

Our Current design

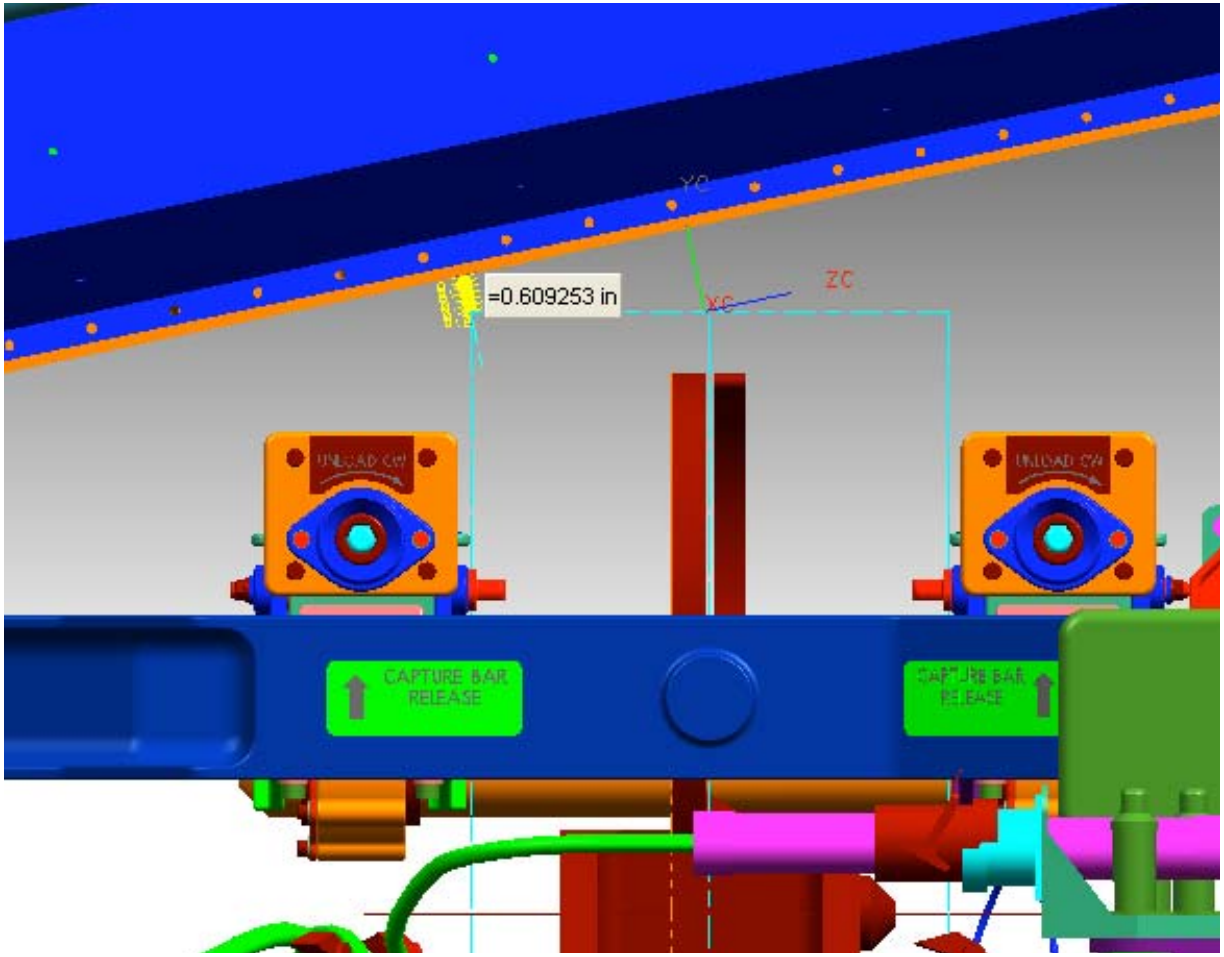
ECAL

Claw Envelope



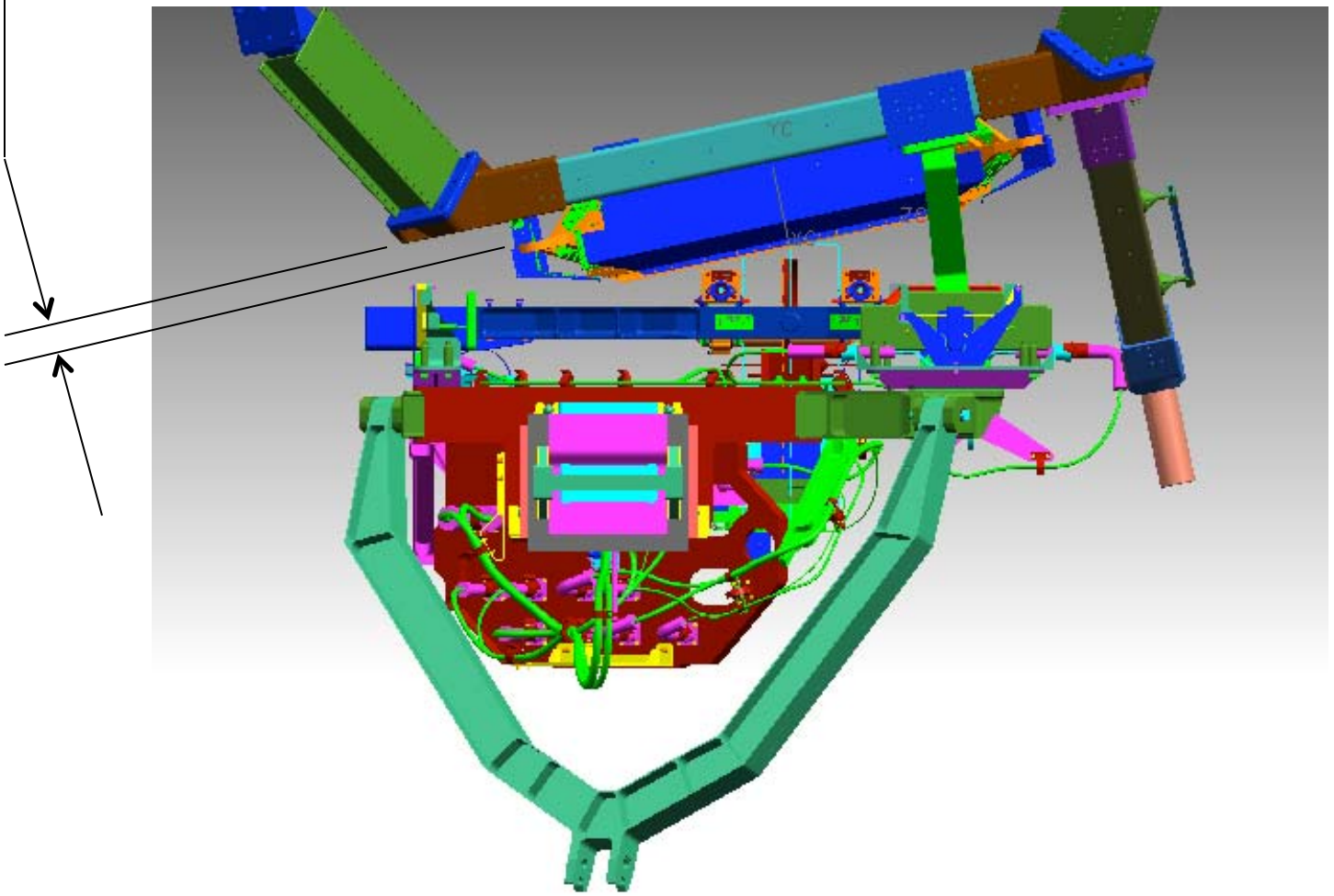
Our Current design

Clearance to Envelope .609 inch (15.4mm)



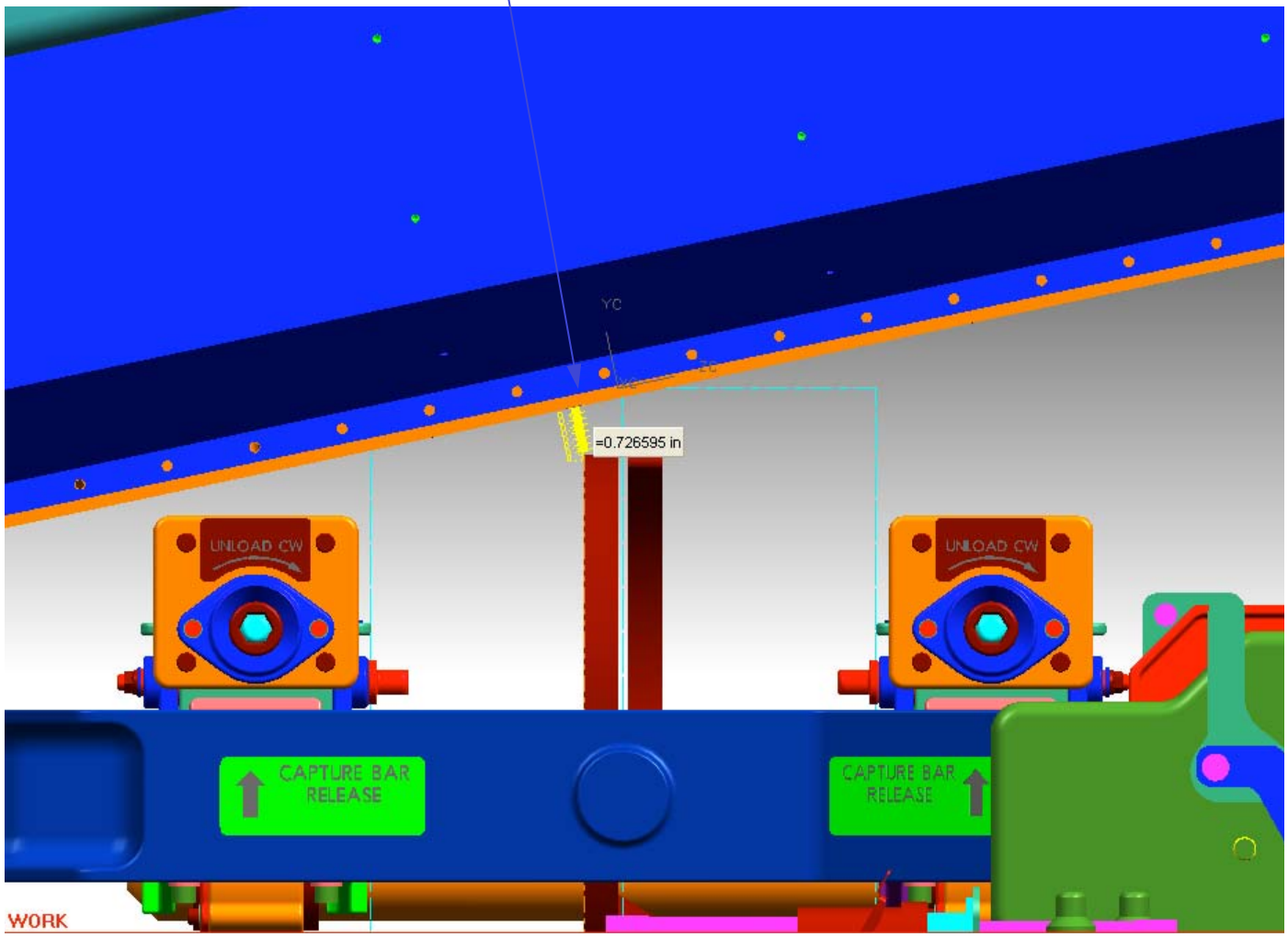
Design with the ECAL
Lowered 40mm (1.57 inch)

2.08 inch (52.8mm) Surface to Surface



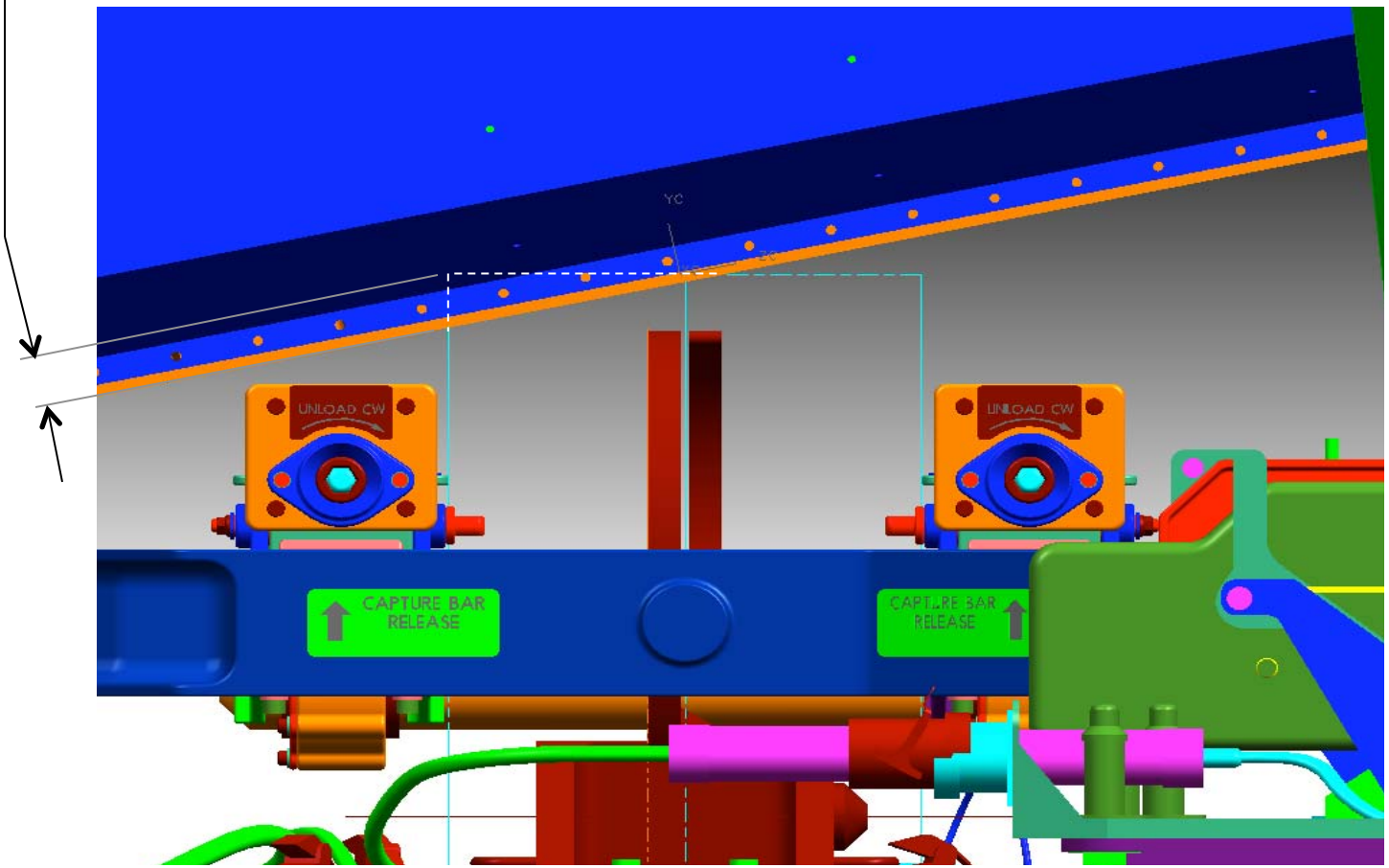
Design with the ECAL
Lowered 40mm (1.57 inch)

Nominal Distance To Claw: .727inch (18.5mm)



Design with the ECAL Lowered 40mm (1.57 inch)

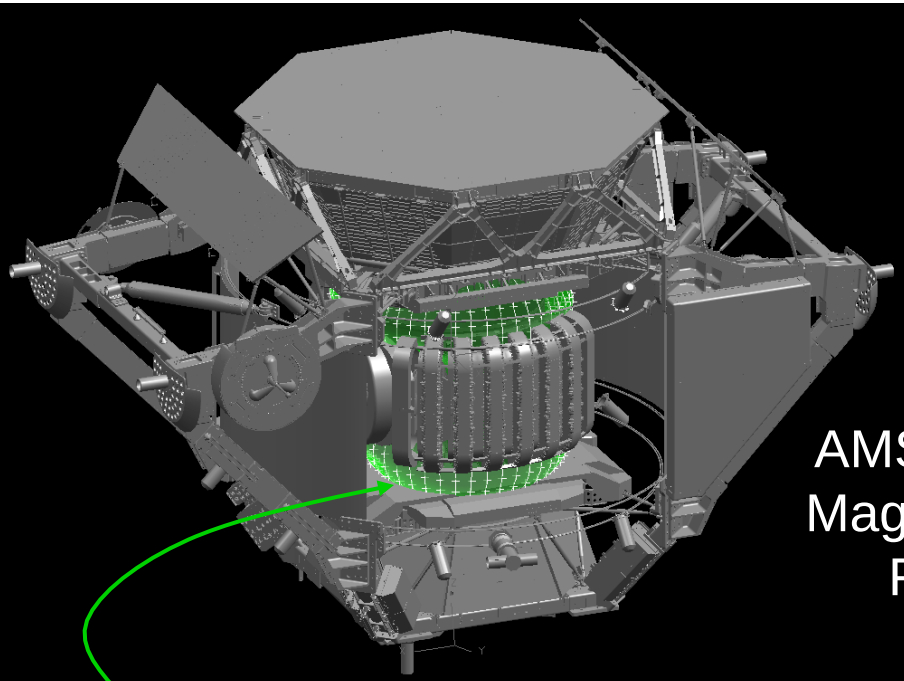
.965inch (24.5mm)
Envelope Violation

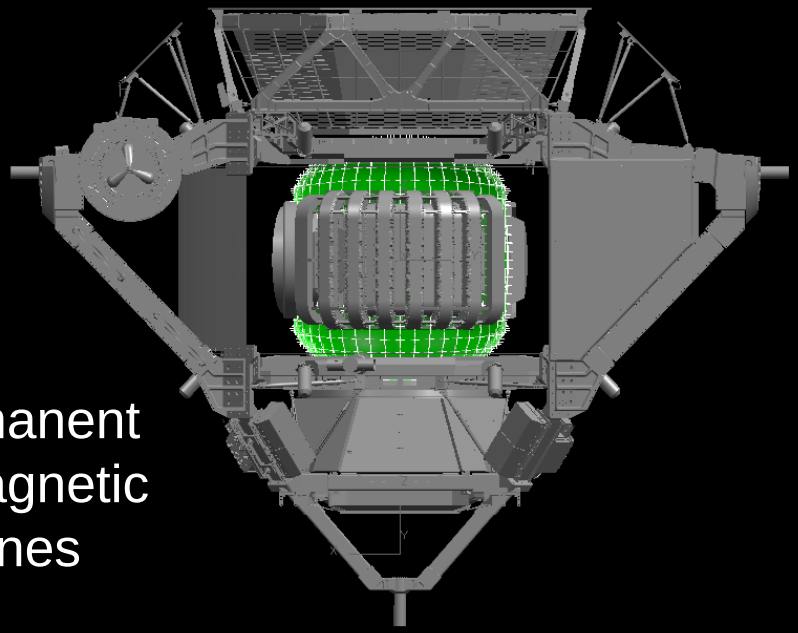


Initial assessments by Cal Brogdon (NASA) and John Cook (Boeing) show that this is acceptable. A waiver will be submitted.

Decreased Magnetic Field

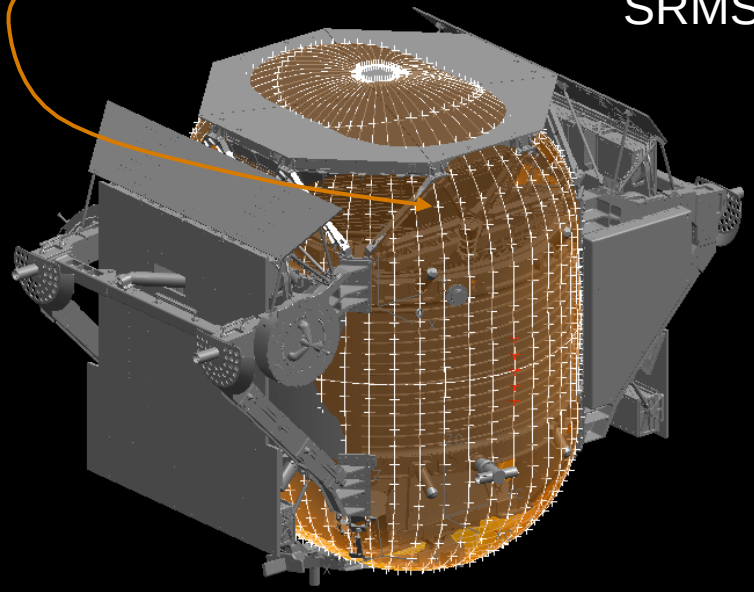
- The permanent magnet field is 6 times smaller than what has already been analyzed and approved for ISS
  - Since everything had already been approved on ISS with larger field, there should be no serious worries about the permanent magnet
- The keep out zone for EVA is 300 gauss, which will now be inside the vacuum case, therefore no concern
- The keep out zone for EVR is 10 gauss and is associated with the SSRMS
  - The 10 gauss line of the permanent magnet is just outside the VC and at the grapple fixtures the field level is only 3 gauss, therefore no concern
- The only final thing that needs to be checked is the SRMS, since it would have never seen any magnetic field at all
  - Since the field strength at the grapple fixture is 3 gauss, this should not be a concern, but we are in the process of confirming with the robotics teams

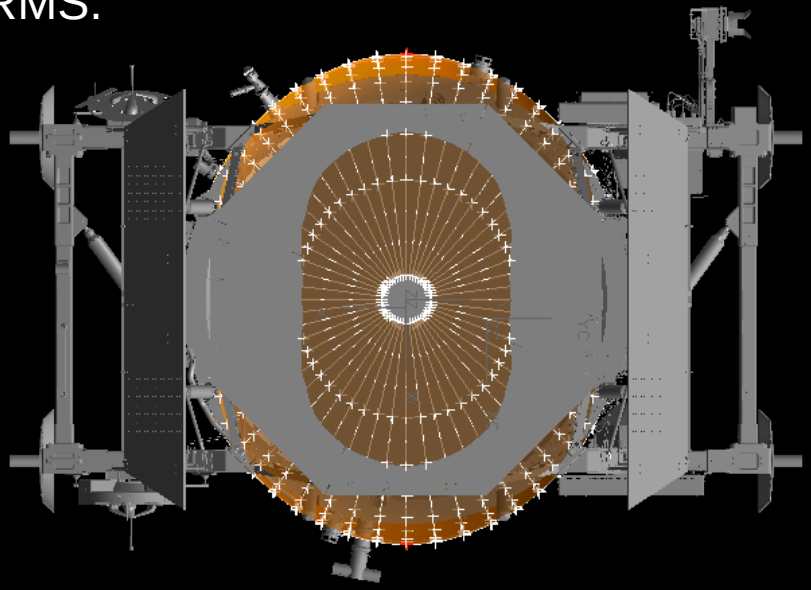




AMS Permanent Magnet Magnetic Field Lines

The 300 Gauss Line is inside the VC, so there are no issues for an EVA Astronaut. The 10 Gauss line is inside the FRGF & PVGF so there should be no issues for the SRMS & SSRMS.





Review of New Design

- In order to ensure that all stakeholders have an opportunity to review and provide comments on the proposed change, we will have a series of reviews
  - Delta CDR – May 4-5, 2010 – JSC
  - Delta Phase III Flight Safety Review – June or July – JSC
  - Delta Phase III Ground Safety Review – July or August - KSC

Flight Safety Review

Hazard Report	Permanent Magnet			Topic
	No Change	Modified	Eliminated	
AMS-02-F01		X		Structures
AMS-02-F02	X			Offgassing
AMS-02-F03			X	Cryosystem
AMS-02-F04		X		Over P Payload Bay
AMS-02-F05		X		Pressure Systems
AMS-02-F06		X		Thrust/Moments
AMS-02-F07		X		Fields, Mag, EMI
AMS-02-F08		X		Elec. Shock
~~AMS-02-F09~~			X	Ionizing Rad.
AMS-02-F10		X		Flammable Mat.
AMS-02-F11	X			Mechanism
AMS-02-F12		X		Mate/Demate
AMS-02-F13			X	Battery
AMS-02-F14		X		EVA Ops
~~AMS-02-F15~~			X	Thermal Extremes
AMS-02-F16		X		Shatterable Material
AMS-02-F17		X		EPDS Damage
AMS-02-F18		X		Rapid Safe/Reconfig.
~~AMS-02-F19~~			X	Excessive Glare
AMS-02-F20		X		Lasers
~~STD-AMS-02-F01~~			X	1230 – Exterior
STD-AMS-02-F02	X			1230 – DDRS-02

Ground Safety Review

Hazard Report	Permanent Magnet			Topic
	No Change	Modified	Eliminated	
AMS02-GHR-001		X		Flammability
AMS02-GHR-002	X			Toxic Materials
AMS02GHR-003			X	Liquefaction of Atmospheric Gases
AMS02-GHR-004		X		Rupture of Pressurized Components
AMS02-GHR-005			X	Exposure to High Pressure Gas Plume
AMS02-GHR-006			X	Excessively Low Touch Temperature
AMS02-GHR-007		X		Asphyxiation
AMS02GHR-008			X	Ionizing Radiation (Deleted at Ph. II)
AMS02-GHR-009		X		Lifting GHE (Redo Tables)
AMS02-GHR-010		X		Structural Stands (Redo Tables)
AMS02-GHR-011		X		Electric Shock
AMS02-GHR-012			X	Acoustics
AMS02-GHR-013		X		Magnetic Fields
AMS02-GHR-014	X			Sharp Edges
AMS02-GHR-015		X		Excessively High Touch Temperature
AMS02-GHR-016		X		Lasers
AMS02-GHR-017	X			Tools

Summary

- Although the time associated with this modification is short, with a delay in the Shuttle launch date to no earlier than mid-November, we believe that this is possible
- Every effort will be made to get buy-in from all parties on the potential impacts to STS, ISS and KSC processing (this review begins that process)